HYDROELECTRIC POWER PLANT

ENGR. RAMON L. PITAO, JR.
CHAIRPERSON, BACHELOR OF SCIENCE IN MECHANICAL ENGINEERING
OF THE NAVAL STATE UNIVERSITY

HYDROELECTRIC POWER PLANT

- In hydroelectric power plants the energy of water utilized to drive the turbine which, in turn, runs the generator to produce electricity. Rain falling upon the earth's surface has a potential relative to the ocean towards which it flows. This energy is converted to shaft where the water falls through an appreciable vertical distance. The hydraulic power is thus a naturally available renewable energy source.
- Hydro or water power is important only next to thermal power. Nearly 20% of the total power of the world is met by the hydropower stations.

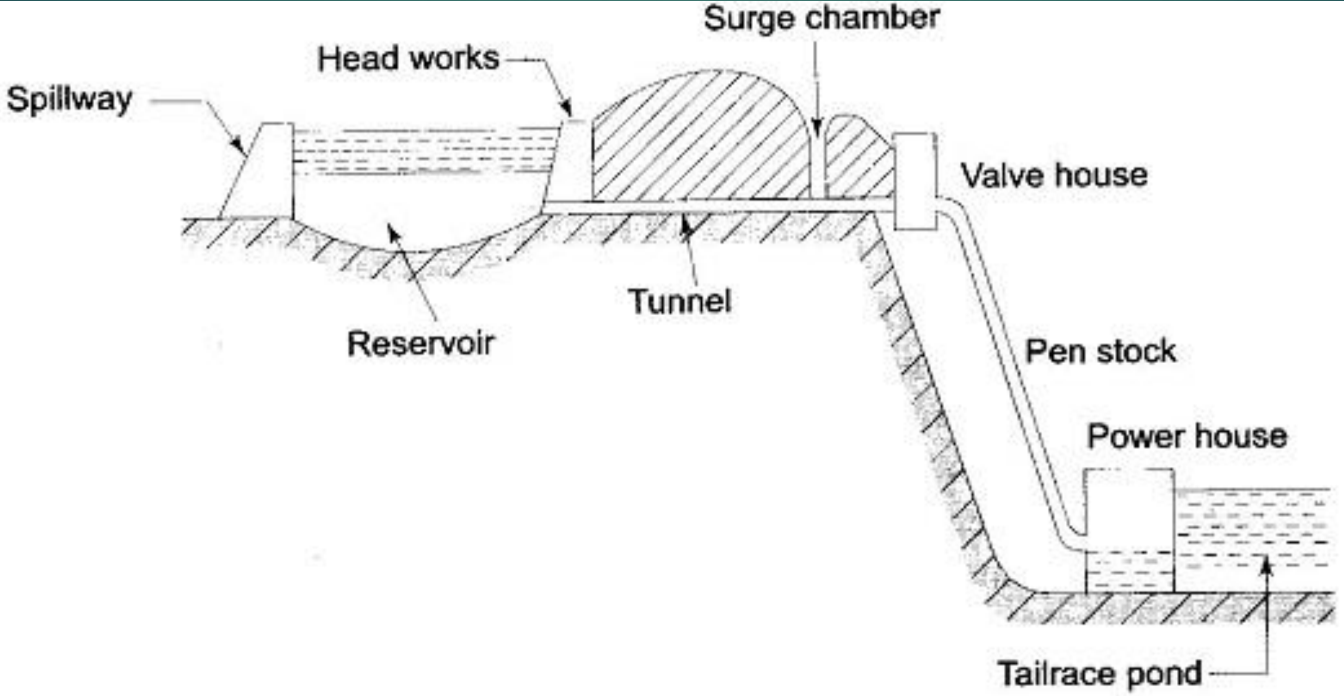

Fig. 1.6 A typical layout for a storage type hydro plant

- FORMULAS:
- Grass head, h_g
- $h_g = Head\ Water\ Elevation - Tail\ Water\ Elevation$
- Friction head loss, h_f
- Darcy's Equation: 2. Morse Equation:
- $h_f = \frac{f\ L\ v^2}{2\ g\ D}$ $h_f = \frac{2\ f\ L\ v^2}{g\ D}$
- Where: f = coefficient of friction
- L = length of penstock, m
- V = velocity, ${}^{m}/_{sec}$
- g = 9.81 ${}^{m}/_{sec}$
- D = inside diameter, m

- Net head, h
- h = $h_g - h_f$
- Penstock efficiency, e
- e = $\frac{h}{h_g}$
- Volume flow of water, Q
- Q = A x v where: A = area v = velocity
- Water Power, P_W
- $P_W = w\ Q\ h$
- where: w = specific weight of water ,
- 9.81 ${}^{KN}/_{m^3}$ or 62.4 ${}^{lb}/_{ft^3}$
- Turbine efficiency, e_T
-
- $e_T = \frac{Brake\ Power}{Water\ Power}$

- $e_e = \frac{Generator\ Output}{Brake\ Power}$
- Turbine Output:
- $W_T = w\ Q\ h\ e_T$
- Generator Output, GO
- GO = $w\ Q\ h\ e_T e_e$
- Generator speed, N
- N = $\frac{120\ f}{P}$
- where: f = frequency   P = no. of poles
- Utilized head, h_w
- $h_w = h\ (e_h)$
- where: $e_h = hydraulic\ efficiency$
- Head of Pelton(Impulse) turbine:
- h = $\frac{P}{w} + \frac{v^2}{2\ g}$

- Head of Reaction (Francis and Kaplan) turbine:
- $h = \frac{P}{w} + \frac{(V_A^2 - V_B^2)}{2\,g} + z$
- Peripheral coefficient, Φ
- $\Phi = \frac{Peripheral\ Velocity}{Velocity\ of\ Jet} = \frac{\pi\,D\,N}{\sqrt{2\,g\,h}}$
- where: D = diameter of runner, m
- N = speed of runner, rps
- g = 9.81 $^{m}/_{s^2}$

- Specific speed of hydraulic turbine:
- 1. $N_s = \frac{N\sqrt{HP}}{h^{\frac{5}{4}}}$ 2. $N_s = \frac{0.2623N\sqrt{HP}}{h^{\frac{5}{4}}}$
- where: N = speed, rpm , h = head, ft
- Total efficiency, e_t
- $e_t = e_h e_m e_v$
- Where: e_m= mechanical efficiency
- e_v = volumetric efficiency
- Turbine type selection base on head, ft

Net Head	Types Of Turbine
Up to 70 ft	Propeller Type
70 ft to 110 ft	Propeller Or Francis
110 ft to 800 ft	Francis Turbine
800 ft to 1300 ft	Francis Or Impulse
1300 ft and above	Impulse Turbine

Note! For small capacity use Propeller Turbine.

For medium capacity turbine use Francis Turbine.

- **Sample Problem 5**
- A Pelton type turbine has 30 m head friction loss of 4.5 m . The coefficient of friction head loss(from moorse) is 0.00093 and penstock length of 80 m . What is the penstock diameter?

- **Solution:**
-
- v = $\sqrt{2\,g\,h}$ h = 30 – 4.5 = 25.5 m
- v = $\sqrt{2(9.81)(25.5)} = 22.37\ m/sec$
- $h_L = \frac{2\ f\ L\ v^2}{g\ D} = 4.5 = \frac{2(0.00093)(80)(22.37)^2}{9.81\ D}$
- **D = 1.686 m** $\rightarrow \mathbf{1686\ mm}$

- **Exercises Problems 16:**
- From height of 65 m, water flows at the rate of 0.85 m^3/sec and is driving a water turbine connected to an electric generator revolving at 160 rpm. Calculate the power developed by the turbine in KW if the total resisting torque due to friction is 540 N.m and the velocity of the water leaving the turbine blades is 4.75 m/sec.